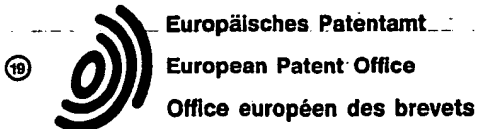


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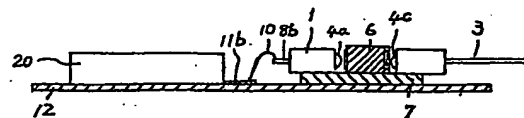
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(54) Optical communication apparatus.

(57) An optical communication apparatus which comprises a printed circuit board, plural circuit elements fixed to the printed circuit board, the circuit elements having terminals extended to the printed circuit board, a photosensitive glass base fixed to the printed circuit board, various optical components accurately fixed to the glass base, the optical elements respectively having plural leads, and corresponding conductive members for electrically connecting the terminals of the circuit elements and the corresponding leads of the optical components, the conductive members each having a rigidity smaller than the rigidity of the corresponding leads of the optical components.

FIG. 1(b)



## Description

## OPTICAL COMMUNICATION APPARATUS

This invention relates to optical communication apparatus, and more particularly to optical communication apparatus having a base to which optoelectronic elements are accurately fixed.

Optical communication systems using optical fibers have been increasingly applied to wider fields. According to such circumstances, the optical circuit components for use in such an optical communication system are required to be compact in size and low in production cost. For example, a wavelength division multi/demultiplexer module is generally used for a wavelength multiplex transmission system. Such module incorporates optoelectronic elements, such as semiconductor lasers, light emitting diodes and photodiodes, and a wavelength division multi/demultiplexer provided with multilayered films and optical fibers. These components are united and accurately fixed to a base made of glass or ceramic. The thus constituted module can achieve compactness and lower production cost, as compared to discrete configuration.

Figures 7a and 7b of the accompanying drawings show a conventional optical wave synthesizer/analyzer module. In Figure 7a, the module incorporates a light-emitting diode (LED) 51, a photo-diode 52, an optical fiber 53, and an optical wave synthesizer/analyzer prism 56 having dielectric film-multilayered filters 55 adhering thereto. Further, the module incorporates optical lenses 54a, 54b and 54c. All the elements are accurately fixed by soldering to a ceramic base 57 which, in turn, is disposed on a printed circuit board 62. Further, a LED driver circuit element 63 and a signal processing circuit element 64 are disposed on the printed circuit board 62 in the vicinity of the base 57. The respective terminals (not shown) of the circuit elements 63 and 64 are connected through printed lines to electrode pads 61a, 61b, 61c and 61d formed on the printed circuit board 62. The leads 58a and 58b of the LED 51 and the leads 59a and 59b of the photodiode 52 are, respectively, connected by soldering to the electrode pads 61a, 61b, 61c and 61d.

In this configuration, the leads 58a and 58b of the LED 51 and the leads 59a and 59b of the photodiode 52 are directly connected by soldering to the electrode pads 61a and 61b and the electrode pads 61c and 61d, respectively. Thus, during the making of the connections, external forces act on the LED 51 and the photodiode 52. As a result, the prescribed positional relationship between the optical components are inevitably changed due to the plastic deformation of the solder used for connection. Further, thermal stress occurs in the solder due to the difference of the thermal expansion coefficient between the base 57 and the printed circuit board 62. Such thermal stress accelerates the creep of the solder and causes a shift in the positional relationship between the optical components. As a result, the reliability of the conventional optical module is significantly deteriorated.

In the above-mentioned configuration, the optical

wave synthesizer/analyzer module is accurately fixed to the flat base. However, there has been disclosed another technique in which optical components are accurately positioned at prescribed positions on the surface of a photosensitive glass base. Figure 8 shows a conventional circuit component. A photosensitive glass base 69 has prescribed grooves 65 to 68 formed in it by accurate etching processes. Elements 52, 53 and 54 and a wavelength division multi/demultiplexer prism 55 are positioned in the grooves 65, 66, 67 and 68, respectively, and the accurately fixed to the base 69 by means of soldering. The element 52 incorporates a combination of optical fibers and lenses. In this configuration, the optoelectronic elements are positioned in a prescribed arrangement with substantially no need for additional adjustments. Thus, this technique has advantages such that the optical circuit components can be manufactured at relatively lower costs.

However, such conventional technique of soldering components to a photosensitive glass still has problems in terms of work efficiency and productivity. Specifically, the soldering portions of the photosensitive glass base may be only etched or, for better quality, a thermal process may be added thereafter to produce a ceramic state. Thus, the types of solder than can be applied to this technique are limited to solders used for ceramic bonding. As a result, there is little flexibility in variation of the solder melting point. Further, ultrasonic oscillation must be additionally applied to achieve satisfactory soldering. Therefore, the work efficiency of assembling optical components becomes lower. Thus, the productivity of manufacturing the optical communication module inevitably becomes lower.

Figure 9 shows an optical circuit component manufactured by use of a conventional technique. In Figure 9, a photosensitive glass base 69 has the prescribed grooves thereon formed by accurate etching processes. An element 53 that incorporates opto-semiconductor elements and lenses is accurately fixed to the base 69. Specifically, in this configuration, the element 53 can be attached to one of the grooves of the base 69 with substantially no need for additional adjustments. Thus, this technique has been applied to manufacturing processes of optical components, such as an optical brancher/coupler and a wavelength division multi/demultiplexer.

However, in the conventional configuration, when the element 53 incorporates an element which generates heat, such as a semiconductor laser, a structural problem in heat radiation arises. Specifically, in Figure 9, one end of a heat-radiating member 70 is attached directly to the element 53. The other end of the member 70 is attached to a heat sink 71. In this configuration, stress occurs with respect to the base 69 and the element 53 when the member 70 is fixed to the heat sink 71. Moreover, the elasticity of the member 70 causes additional stress with respect to the base 69 and the element 53. The stresses may

cause the element 53 to deteriorate in optical and mechanical characteristics, such as by deviation of the optical axis or other damage.

Accordingly, one object of the present invention is to provide an optical communication module substantially free from thermal stress-caused defects.

Briefly, in accordance with one aspect of the present invention, there is provided an optical communication apparatus comprising a first body secured to a second body, at least one optoelectronic component secured to the first body and having a conductive lead, and a conductive member on said second body, characterised in the provision of an electrical conductor connected to said conductive lead and to said conductive member, said conductor having a rigidity less than that of said conductive lead.

In order that the invention may be more readily understood, it will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1a is a plan view illustrating a first embodiment according to the present invention;

Figure 1b is a cross-sectional view taken along line A-A of Figure 1a;

Figure 2a is a plan view illustrating a second embodiment according to the present invention;

Figure 2b is a cross-sectional view taken along line A-A of Figure 2a;

Figure 3a is a plan view illustrating a third embodiment according to the present invention;

Figure 3b is a cross-sectional view taken along line A-A of Figure 3a;

Figure 4 is a perspective view illustrating an essential part of a fourth embodiment according to the present invention;

Figure 5 is a perspective view illustrating an essential part of a fifth embodiment according to the present invention;

Figure 6 is a perspective view illustrating an essential part of a sixth embodiment according to the present invention;

Figure 7a is a plan view illustrating a conventional wavelength division multi-demultiplexer transmitter/receiver;

Figure 7b is a cross-sectional view taken along line A-A of Figure 7a;

Figure 8 is a perspective view illustrating an essential part of another conventional wavelength division multi-demultiplexer transmitter/receiver; and

Figure 9 is a perspective view illustrating an essential part of still another conventional wavelength division multi-demultiplexer transmitter/receiver.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to Figure 1 thereof, a first embodiment of this invention will be described.

In Figures 1a and 1b, a light emitting diode (LED), a photo-diode (PD) 2 and an optical fiber 3 are

united, respectively, with optical lenses 4a, 4b and 4c so as to form collimators. The collimators convert light emitted by the LED and the optical fiber into collimated light beams and produce the same. The collimators also receive collimated light beams and focus the same on prescribed optical positions. The LED 1, the photo-diode 2 and the optical fiber 3 are fixed by soldering or the like to a first body 7 together with a prism 6 having dielectric multilayered filters 5. They coincide with each other in terms of their optical axes. Leads 8a and 8b of the LED 1 and leads 9a and 9b of the photo-diode 2 are connected through gold wires 10 to electrode pads 11a, 11b, 11c and 11d, respectively, on a second body in the form of a printed circuit board 12. The electrode pads 11a, 11b, 11c and 11d are connected, respectively, through printed lines to the terminals of a LED driver circuit 20 and a receiver circuit 21. In this case, the gold wires 10 are connected to provide a curved portion in the middle of each wire 10.

Specifically, the gold wires 10 are about 25  $\mu$ m in diameter and have a rigidity much smaller than that of the respective leads 8a, 8b, 9a and 9b. Thus, substantially all of the stresses produced by the difference in thermal expansion between the base 7 and the printed circuit board 12 caused by changes of environmental temperatures are absorbed by the curved portions of the gold wires 10. As a result, such stresses are substantially eliminated from the fixed portions of the LED 1 and the photo-diode 2. Therefore, the deterioration in optical coupling characteristics caused by the shift in the positional relationships between the optical components can be avoided. Also the creep of the solder used for connecting the optical components is not accelerated. Further, the curved portions of the gold wires 10 can absorb vibrations.

Figures 2a and 2b show a second embodiment of the present invention. In Figure 2a, electrode blocks 13 and 14 made of ceramic or the like are provided between the LED 1 and the LED driver circuit 20, and also between the PD 2 and the signal processing circuit 21. The electrode blocks 13 and 14 have electrode patterns 15a, 15b, 15c, and 15d formed thereon. Leads 8a, 8b, 9a and 9b of an LED 1 and the PD 2 are respectively connected to the electrode patterns 15a, 15b, 15c and 15d through gold wires 10. In FIGURE 2b, the electrode pattern 15b extends so as to form a side electrode pattern 17b. The side electrode pattern 17b is connected by soldering to one of terminals of the LED driver circuit 20 through a printed line 16b.

In this embodiment, the heights of the electrode blocks 13 and 14 are substantially the same as those of the leads 8a and 8b of the LED 1 and the leads 9a and 9b of the PD 2. This facilitates the work of wire bonding which is usually performed under the microscope. Moreover, the gold wires 10 and the electrode patterns 15a, 15b, 15c and 15d are connected by the use of techniques such as thermal pressure bonding or ultrasonic wave pressure bonding. Thus, the adverse effects caused by the heat generated by soldering the electrode patterns 17 and printed lines 16 can be significantly avoided.

FIGURES 3a and 3b show a third embodiment of

the present invention. In FIGURE 3a, a base 7 to which optical components are fixed is incorporated in a case 19. Connection terminals 18a, 18b, 18c and 18d are provided on the sidewalls of the case 19 and electrically insulated each other. The heights of the connection terminals 18a, 18b, 18c and 18d are substantially the same as those of leads 8a, 8b, 9a and 9b of the LED 1 and the PD 2. The connection therebetween is achieved by the use of gold wires 10.

In this embodiment, substantially all of stresses produced by the difference of thermal expansion between the case 19 and the base 7 caused by changes of environmental temperatures are absorbed by the curved portions of the gold wires 10. Thus, even when connection and disconnection with peripheral electron circuits are repeated, the deterioration in the optical coupling characteristics can be avoided. As a result, the work efficiency of manufacturing the module according to the present invention can be significantly enhanced.

Next, a fourth embodiment according to the present invention will be described with reference to FIGURE 4. In the above-described embodiment, various optical components are accurately fixed by soldering directly to the flat base. However, in this embodiment, as shown in FIGURE 4, a base 22 is made of photosensitive glass particularly prepared by the chemical etching process. The glass base 22 has grooves 23, 24, 25 and 26 formed by the use of a selective etching process.

Specifically, only the portions of the base 22 on which the grooves are formed are selectively exposed to ultraviolet rays, thermally processed, and etched. Further, the shaded portion, i.e., the entire upper surface of the base 22 is coated with a three-layer metal film 27. Otherwise, at least all the inner walls of the grooves must be coated with such metal film. The metal film 27 consists of three layers made of chromium (closest to the base surface), nickel and gold (top). The thickness of the gold layer is 2  $\mu$ m at a minimum. Within the respective grooves 23, 24, 25 and 26 coated with the metal film 27, optical components (not shown) are accurately fixed by soldering. Thus, such soldering can be achieved by use of the solder which is employed to connect conventional electric circuits. Naturally, the solder for glass or ceramics can also be used. As a result, the melting points of the solder to be used can be freely selected depended on the properties of the optical components to be fixed to the base.

In addition, the use of the solder which is employed to connect conventional electric circuits can eliminate such a particular process as application of ultrasonic oscillation. Thus, the work efficiency of assembling optical components can be significantly enhanced. As a result, the productivity of manufacturing the optical circuit components can also be improved.

FIGURE 5 shows a fifth embodiment according to the present invention. In FIGURE 5, an isolation region 28 in which no metal film is coated is provided on the part of the base 22. Thus, the portions to which optical components are fixed can be electrically insulated. The isolation region 28 is formed by

the use of a masking technique. When the light emitting portion is isolated from the light receiving portion, their high frequency characteristics are improved. As a result, a satisfactory electrical isolation can be achieved between the light-emitting and -receiving portions. Therefore, the use of this base can achieve a higher transmission speed. In addition, the electric potentials of the light-emitting and -receiving portions can be freely determined. Thus, peripheral electronic circuits can be easily mounted without limitation in terms of electric potentials.

Next, a sixth embodiment according to the present invention will be described with reference to FIGURE 6. In FIGURE 6, a package 1 incorporates a LED or semiconductor laser and a collimating lens. A photosensitive glass base 22 has a groove 25 formed by accurate etching processes. The entire upper surface of the base 22 is coated with the same metal film as that in the fourth and fifth embodiments. A heat sink 29 is made of alumina plated with gold. The package 1 is accurately fixed within the groove 25 by soldering.

The package 1 is made of a material, such as an alloy of tungsten and copper, and is satisfactorily thermally combined with the semiconductor laser chip. A heat-radiating member 30 is made of copper. One end of the member 30 is fixed to a portion close to a portion to which the package 1 is attached. The other end of the member 30 is fixed to the upper surface of the heat sink 29. Both ends are fixed by soldering. However, the soldered portions are not shown. In this configuration, heat generated from the semiconductor laser during operation is conducted to the heat sink 29 by way of the package 1, the base 22, the heat-radiating member 30, and the solder therebetween. As a result, satisfactory heat radiation can be efficiently achieved without the occurrence of stresses with respect to the package 1 and the base 22.

In this embodiment, the soldering process is performed as follows. First, the base 22 is entirely heated, and the package 1 and the member 30, both being previously plated with solder, are attached simultaneously to the heated base 22. The solder between the base 22 and both the package 1 and the member 30 is melted, and the connection therebetween is completed. The base 22, package 1 and the member 30 are thus united, and then accurately fixed to the heat sink 29 by soldering.

Moreover, the connection of the base 22, package 1, member 30 and heat sink 29 is achieved by soldering. However, this connection may also be achieved by use of any other materials having a satisfactory thermal conductivity, such as polymer adhesive, i.e., epoxy resin, or the like, for example.

Obviously, numerous additional modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

# Claims

1. An optical communication apparatus comprising a first body (7, 22) secured to a second body (12, 19, 29), at least one optoelectronic component (1) secured to the first body and having a conductive lead (8b), and a conductive member (11b) on said second body, characterised in the provision of an electrical conductor (10) connected to said conductive lead and to said conductive member, said conductor having a rigidity less than that of said conductive lead.

2. The apparatus of claim 1, characterised in that said conductor is a metal wire, ribbon or meshed wire.

3. The apparatus of claim 2, characterised in that said conductor is a wire of gold or aluminium or copper and has a maximum diameter of about 100  $\mu\text{m}$ .

4. The apparatus of claim 2, characterised in that said conductor is a ribbon or meshed wire of gold or aluminium or copper and has a maximum width of about 1 mm and has a

maximum thickness of about 100  $\mu\text{m}$ .

5. The apparatus as claimed in any preceding claim, characterised in that the second body has a planar surface and the conductive member on the second body and the conductive lead are positioned substantially equidistant from said planar surface.

6. The apparatus as claimed in any preceding claim, characterised in that the component is located in a groove in the first body.

7. The apparatus as claimed in claim 6, characterised in that the first body is of glass or ceramic with a metal film on the wall of the groove.

8. The apparatus as claimed in any preceding claim characterised in that the second body is a printed circuit board.

9. The apparatus as claimed in any of the claims 1 to 7, characterised in that the first body has a heat sink secured thereto.

10. The apparatus as claimed in claim 6, characterised in that a heat-radiating member is attached to the first body adjacent to the groove and to a heat sink secured to the first body.

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FIG. 1(a)

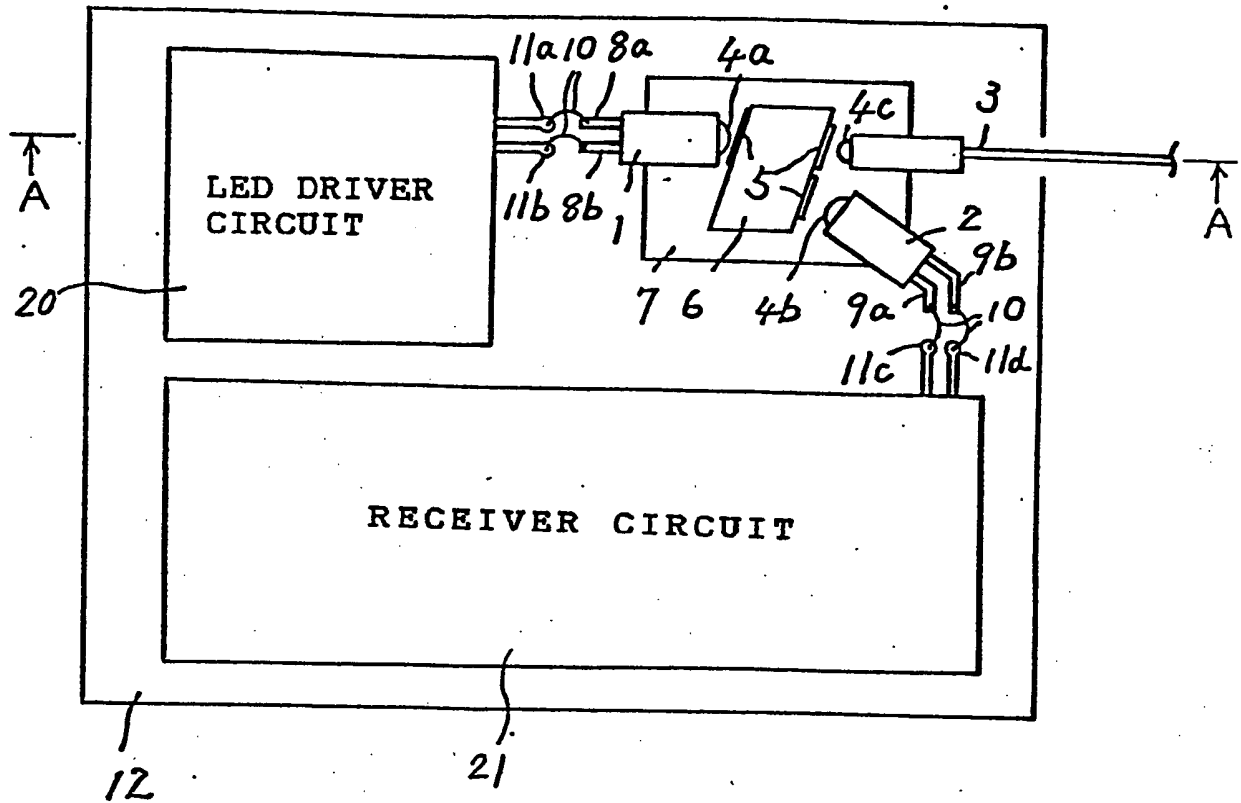


FIG. 1(b)

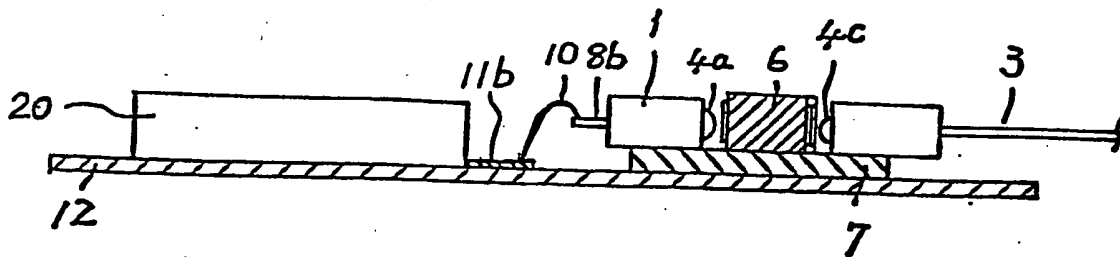


FIG. 2(a)

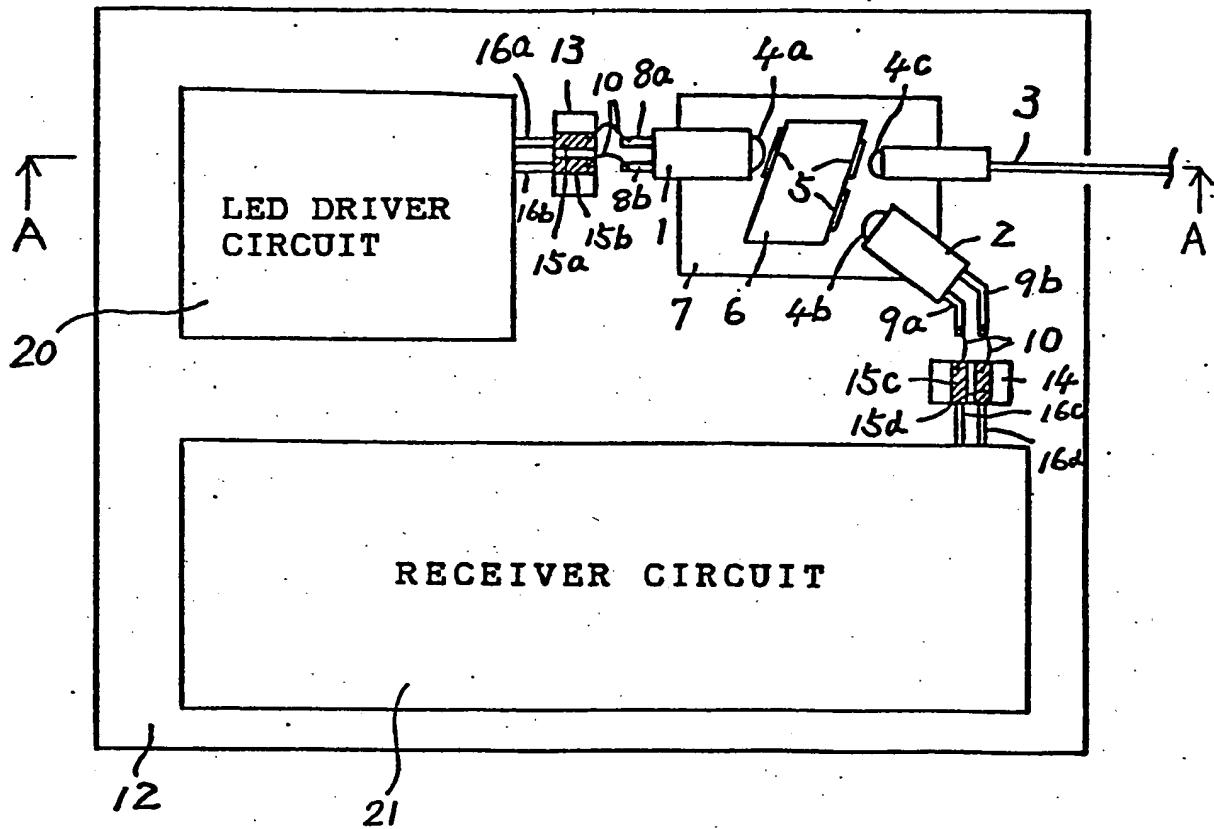
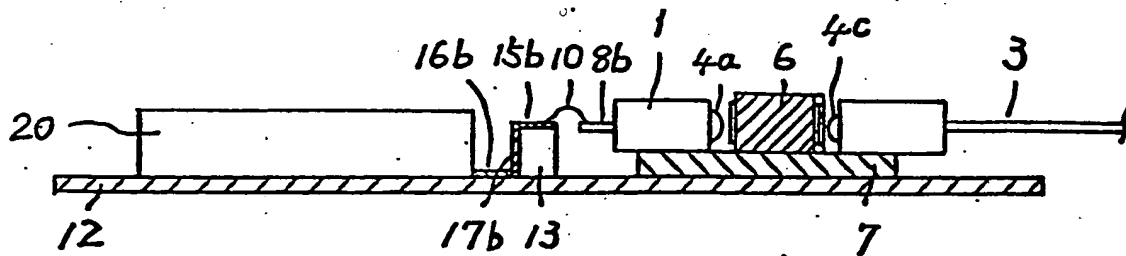
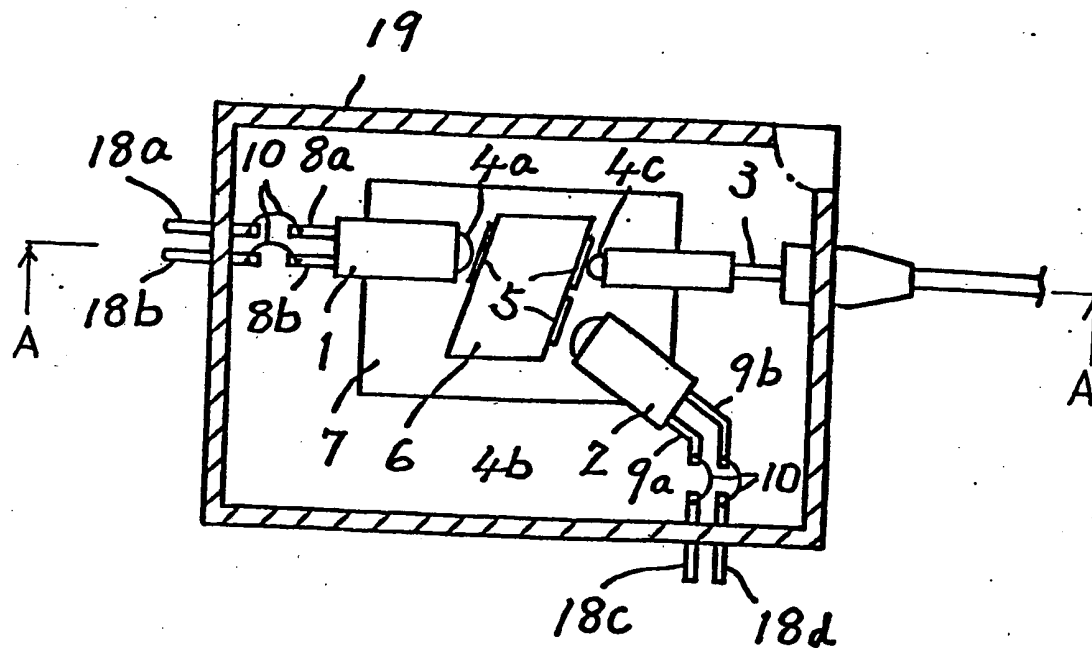


FIG. 2(b)



**FIG. 3(a)**



**FIG. 3 (b)**

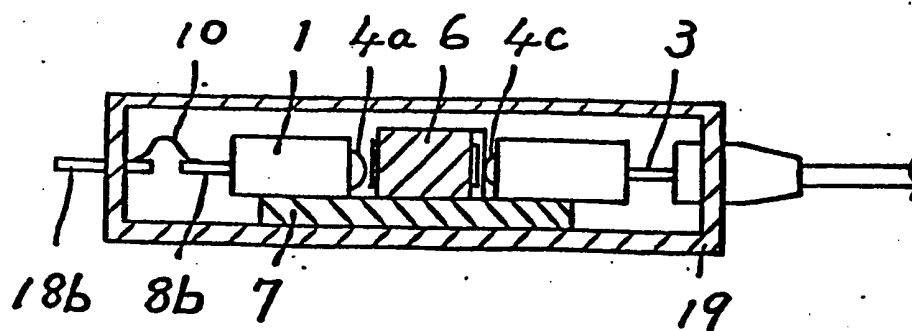




FIG. 4

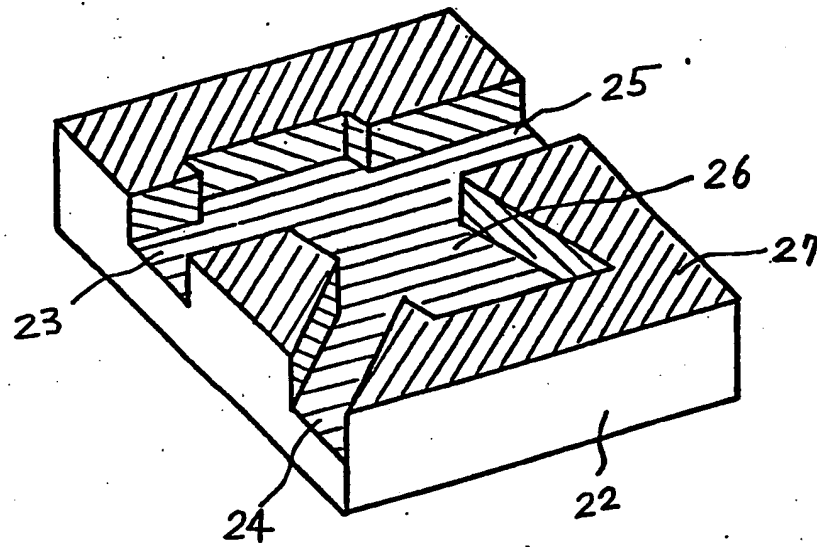


FIG. 5

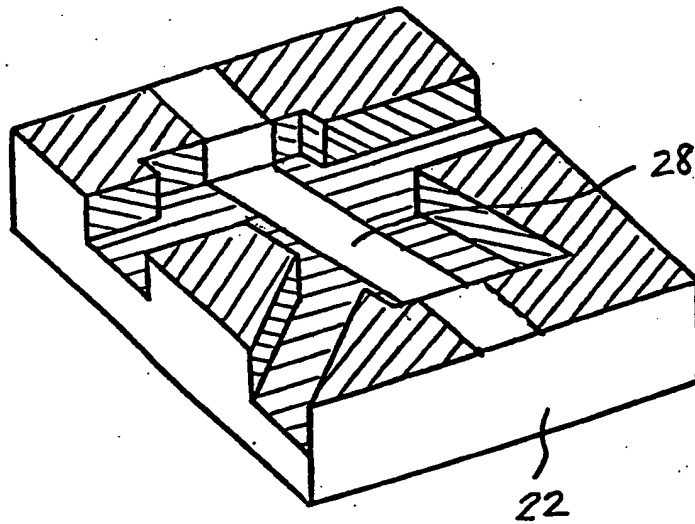
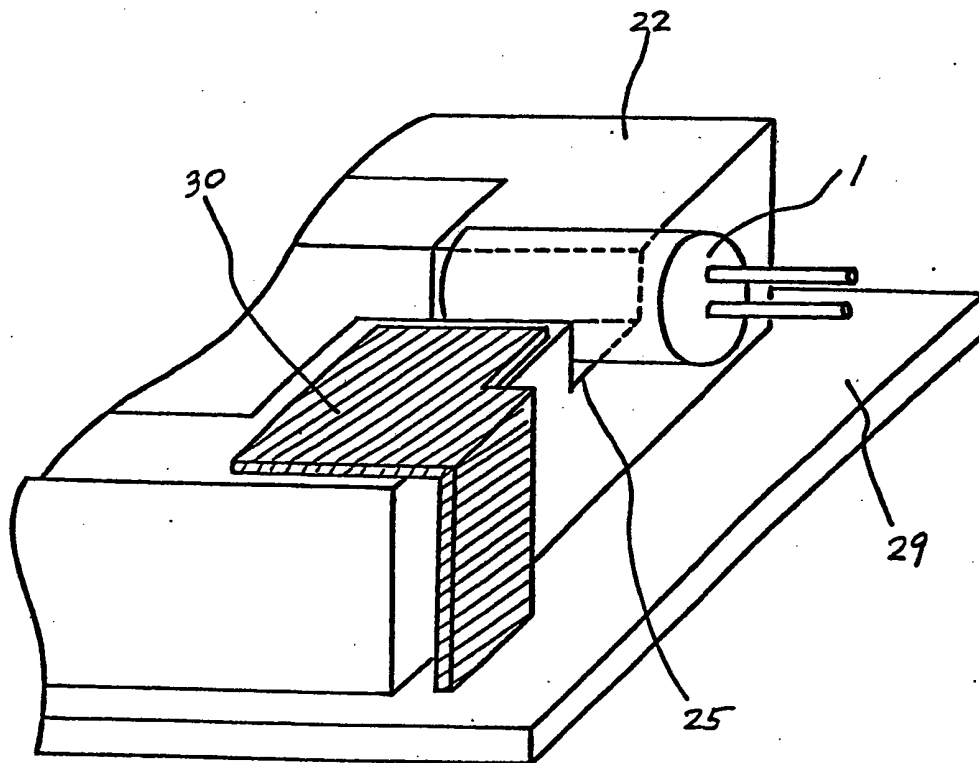
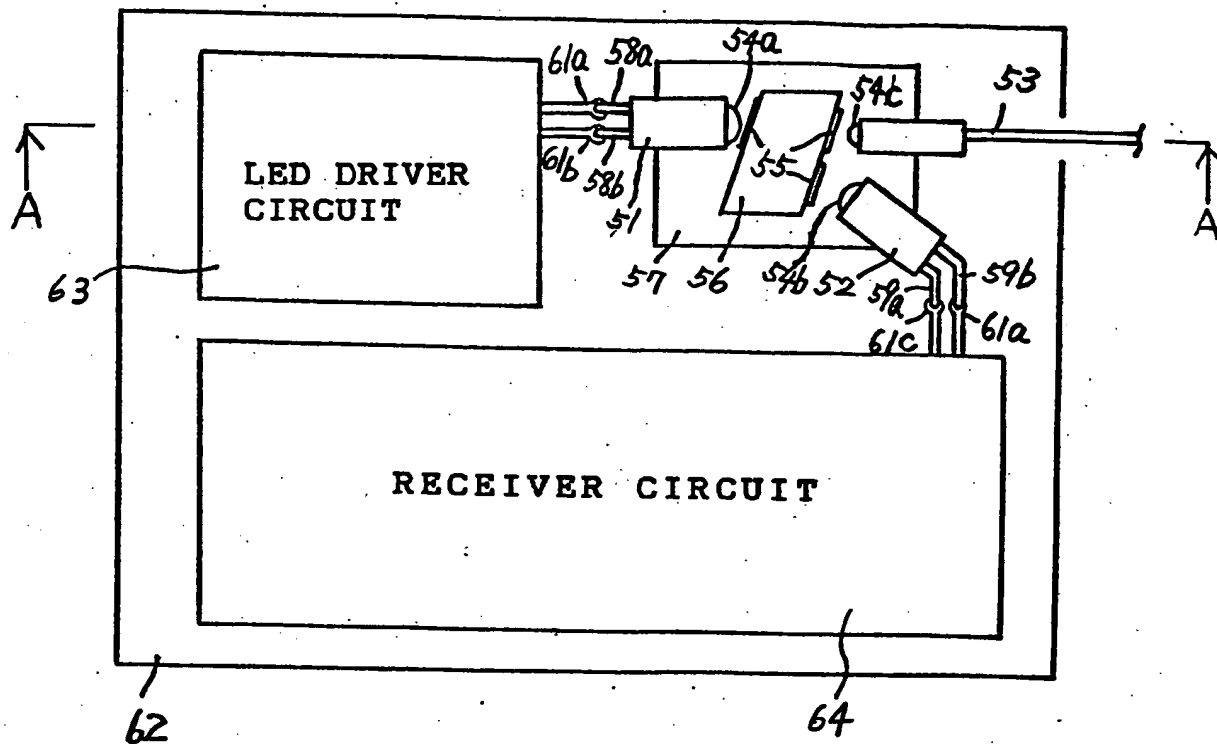


FIG. 6



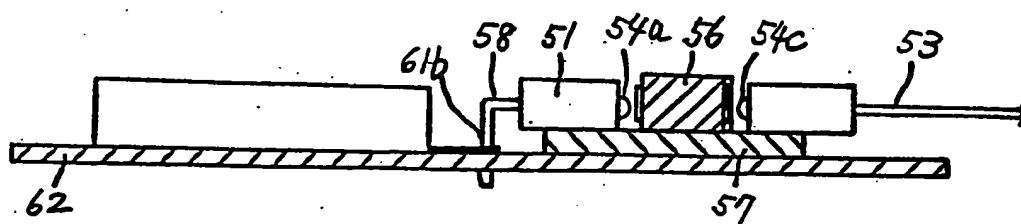
**FIG. 7(a)**

## PRIOR ART



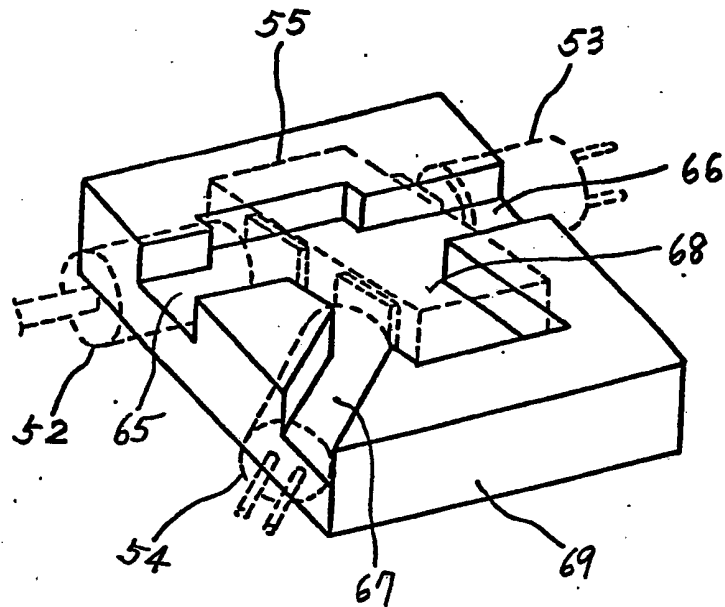
**FIG. 7(b)**

## PRIOR ART



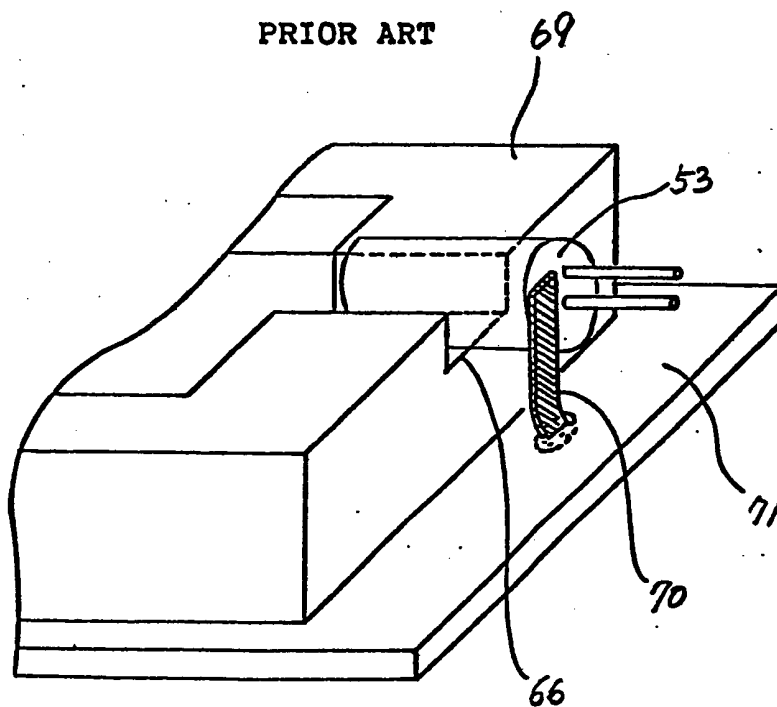
**FIG. 8**

PRIOR ART



**FIG. 9**

PRIOR ART



(19)



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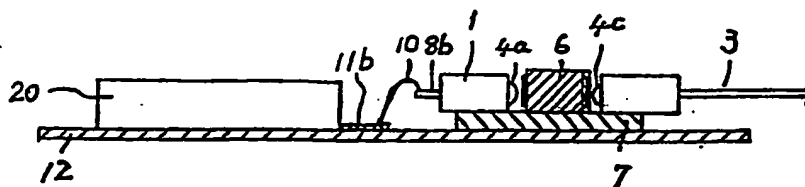
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08.05.91 Bulletin 91/19(71) Applicant: **KABUSHIKI KAISHA TOSHIBA**  
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London EC1R 0DS(GB)(54) **Optical communication apparatus.**

(57) An optical communication apparatus which comprises a printed circuit board (12), plural circuit elements (20, 21) fixed to the printed circuit board, the circuit elements having terminals (11a, 11b) extended to the printed circuit board, a photosensitive glass base (71) fixed to the printed circuit board, various optical components (1, 2) accurately fixed to the glass base, the optical elements respectively

having plural leads (8a, 8b), and corresponding conductive members (10) for electrically connecting the terminals of the circuit elements (11a, 11b) and the corresponding leads of the optical components, the conductive members each having a rigidity smaller than the rigidity of the corresponding leads of the optical components.

**FIG. 1(b)**



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## EUROPEAN SEARCH REPORT

Application Number

EP 89 30 1985

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X,Y	DE-A-2 734 798 (TEXAS INSTRUMENTS) * Pages 15-17; figures 1-3 * - - - -	1-10	G 02 B 6/42 H 01 L 33/00 H 05 K 3/32
Y	GB-A-2 017 958 (SPERRY RAND) * Page 2, lines 52-55; figure 1 * - - - -	1,2,4	
Y	US-A-4 495 704 (J.M. HAMMER) * Column 4, lines 16-37; figure 3 * - - - -	1-4,9,10	
Y	US-A-4 119 363 (I. CAMLIBEL et al.) * Column 3, lines 44-51; figures 1,2 * - - - -	1-4,9,10	
Y	PATENT ABSTRACTS OF JAPAN, vol. 5, no. 191 (P-92)[863], 5th December 1981; & JP-A-56 117 211 (MATSUSHITA DENKI SANGYO) 14-09-1981 * Total * - - - -	1	
Y	CONFERENCE ON LASERS AND ELECTRO-OPTICS, San Francisco, California, 9th - 13th June 1986, pages 332-333; K. KATOH et al.: "THS5 Three-channel wavelength-division-multiplexing transceiver module assembled without an adjustment process" * Total * - - - - -	5-10	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G 02 B H 01 L H 01 S
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of search 22 February 91	Examiner MALIC K.
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